The Journal of Medicine and Science www.tjms.in

Short Commentary TJMS 2022; 01(01): 14-16

# Dynamic Pupillometry – An indigenous non-invasive screening tool for clinical utility

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**ARTICLE INFO**

**Article history:**

Received 10 August 2022

Revised 12 August 2022

Accepted 15 August 2022

**Keywords:**

Dynamic Pupillometry

Non-invasive screening

Pupillometers

Prognosis

Indigenous

## INTRODUCTION

Non-invasive diagnostic practices have been emerging expeditiously in the scientific medical field, which are more preferred, convenient, and effective than invasive procedures. Most of these practices are playing a crucial role in the diagnosis of several clinical diseases using computer-aided imaging devices. The modern non-invasive procedures commonly employed in the clinical sectors are X-ray, Ultrasonography (USG), Computed Tomography (CT), Magnetic Resonance Image (MRI), functional MRI (fMRI) and Positron Emission Tomography (PET)scans [1]. The Pupillometers are one such imaging instrument to measure the pupil size and reactivity. Recently the utility of computerized or portable, handheld pupillometer has been expanding in health care systems [2]. Previous research studies had revealed that pupillometers have neurodiagnostic significance in various clinical and experimental studies [3,4]. The Dynamic Pupillometry (DP) is also gaining empirical significance to evaluate the depiction of diseases and underlying pathophysiological mechanisms involving in the disease by computing Pupillary Light Reflex (PLR). The quantitative pattern of light reflex is a fundamental component of some neurological assessment, and their variables signify the neurological deficits in various diseases and the prognosis in response to an effective treatment regimen [5]. An impaired pupil response may found in neurological deterioration and poor prognosis. Pupillometer is a self-contained camera that objectively measures static pupil diameter and dynamic pupil response to a standard light stimulus using Infra-Red (IR) videography [6]. The earlier pupillometers in the 1960s were time-consuming, low precision due to the less frame rate. But recently, automated pupillometers are advanced with digital imaging technology, which can provide acceptable pupil measures. However, these pupillometers are too expensive and unaffordable to a regular clinical setup [7].

There is a considerable development in digital imaging tools in the past few years due to the accessibility of cameras with optimal resolution and frame rate. The encroachment of unique optics in these digital cameras conquers hassle-free capturing of good quality images. These cameras can be employed to video graph the pupil reaction under multiple wavelengths of light. The mesopic vision causes pupil dilation captured under Infrared illumination, and photopic vision leads to pupil constriction under bright light illumination [8, 9]. The entire pupil response can be video graphed, which includes maximum dilation to maximum constriction. It can analyze from individual frames of video for pupil diameter using image analysis. Thus a customized simple web camera with an optimum frame rate can record pupil response to light, which provides a quantitative analysis of PLR using infrared videography [10, 11].

### Why we need Quantitative measures of PLR?

The pupil is the central aperture of the iris that controls the intensity of the light falling on the retina. The pupils are circular, bilaterally symmetrical, and centric positioned within the iris of healthy individuals. The

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Cite as: Siva Kumar A V et al. Dynamic Pupillometry – An indigenous non-invasive screening tool for clinical utility. The Journal of Medicine and Science 2022; 01(01): 14-16.

pupil size varies in adults from 2 – 4 mm in photopic vision and 2 – 8 mm in scotopic vision controlled by two antagonistic muscles, i.e., Sphincter pupillae and dilator pupillae. A bright light stimulus, accommodation reflex reduces pupil size due to the contraction of sphincter pupillae (Miosis) mediated by parasympathetic stimulation. The other stimulants, like cognitive load, attention, alertness, and darkness, cause dilation of the pupil (mydriasis) due to the contraction of dilator pupillae via the sympathetic activation. So the Pupillary light reflex (PLR) examination is a fundamental, comprehensive neurological index in several clinical disorders. The swinging flashlight test (pen torch test) is often employed to evaluate pupil function as a routine clinical examination for bedside patients. However, it does not provide precise quantitative values instead expressed in a qualitative manner (PERRLA – Pupils are round, reactive to light and accommodation), which has a subjective bias, and there is a considerable interobserver variability which leads to inadequate interpretation. The pupil examination of neurosurgical and ICU patients are often essential as they cannot participate in the clinical evaluation due to their severe condition or sedation. In general clinical practice, the subjective pupil examination may be inadequate by stimulus strength, duration of light stimulus surrounding ambience and observer visual acuity, which makes unreliable. So to circumventing the subtle of manual examination of the pupil, the computerized or handheld pupillometers have been employed for objective measurement of pupillary parameters.

**Applications of Pupillometry and its role in clinical utility:**

The Dynamic Pupillometry indices help in the assessment of autonomic dysfunction [12, 13] as the PLR graphic pattern has two limbs. The downward limb is the constriction phase represents parasympathetic activation to a light stimulus, and the upward limb is the subsequent redilation phase, indicates sympathetic activation after the light exposure. The PLR evaluation is user friendly and convenient for participation than other traditional tests for autonomic assessment. So the lesions in ANS like Addie's tonic pupil, Horner's syndrome, and lesion in the oculomotor nerve can also be found out using PLR. It is also tailored for the diagnosis of cholinergic deficiency syndromes like Parkinson's and Alzheimer's diseases where PLR is altered [14]. The pupillometry also reveals emotions, attention, and evaluation of cognitive disabilities [15, 16]. It is the easiest method than EEG and fMRI for the measuring of prefrontal activity and Visio - spatial discrimination as they are reflected in pupil response and magnitude of PLR [17]. The pupil reactivity also diminished in raise in intracranial pressure after traumatic brain injury, which in turn becomes worst associated with a lack of prognosis [18]. So the PLR has been designated as a prognostic variable in head injury and critical care patients. Pupil monitoring is essential in intensive care unit patients as they reflect the brain stem activity [19]. The abnormal pupil response is also associated with other diagnostic variables like pulse wave velocity [20].

Thus Dynamic pupillometry can be used as a non-invasive screening tool in various clinical evaluations. It is a novel technique that offers a promising approach portable, inexpensive and simple for measurement of the static and dynamic pupil. The Cost effective pupillometer can be made from an ordinary camera which optimum frame rate to videograph and quantify the PLR to interpret the status of clinical condition.

**Funding Source**

None

**Peer-Review**

This article has been reviewed by

1. Dr. Moorti A, Associate Professor, Department of Physiology, Coimbatore Medical College and Hospital, Coimbatore, India.

2. Dr. Jeevakala S, Associate Professor, Department of Ophthalmology, Coimbatore Medical College and Hospital, Coimbatore, India.

**Declaration of Competing Interest**

None

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